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ABSTRACT

This student fieldbook provides exercises for a three-week course in limnology. Exercises emphasize applications of knowledge in chemistry, physics, and biology to understand the natural operation of freshwater systems. Fourteen field exercises include: (1) testing for water quality: (2) determination of water temperature, turbidity, dissolved oxygen, carbon dioxide, alkalinity, acidity pH, phosphates, nitrates: (3) sampling at shoreline, in open water, and bottom mud: and (4) examination of samples at those levels. Notes for four telelessons, data tables, and apparatus diagrams are also included. (CS)

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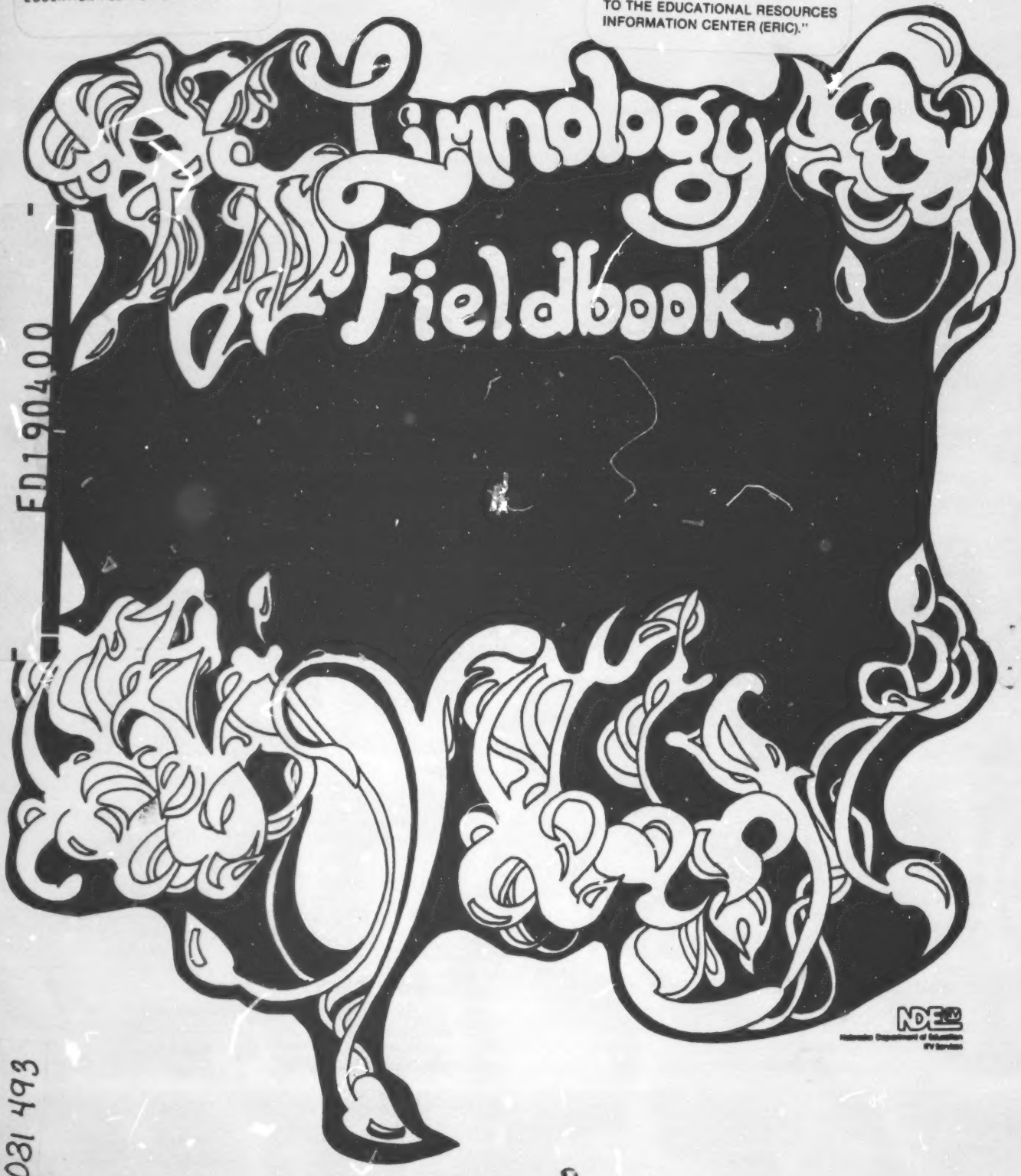
Limnology Fieldbook



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LIMNOLOGY

Student Fieldbook

by Michael Jones

developed under the direction of
Dr. Roger Macklem

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Introduction

One of the branches of science which biology students can pursue is limnology. In limnology, researchers use knowledge of chemistry, physics and biology to understand the natural operation of freshwater systems. In this three-week course, the chemistry and physics involved will be elementary, but you will be able to apply some simple science concepts to your own investigations.

Your studies will encompass many exercises dealing with physical, chemical and biological aspects of freshwater. You'll visit a nearby lake to take samples and record observations and data; you'll do many experiments with the water samples and work with the data. Your class as a whole will synthesize the small group work into a good explanation of the operation of a freshwater system. You will also have the opportunity to do a student project of your own design – the scope of the course will expand as you let yourself become involved in it.

Welcome to a new experience.

Michael Jones

Why You Have a Field Book

This Field Book will be your constant companion for the next three weeks. It provides material you will need for the study of lakes and streams.

Within this book are laboratory exercises, data tables, explanations, equipment diagrams and note pages. All your data and record keeping will be done in this book. When you have completed your limnology studies, you will have a permanent record of your work to keep.

A Way To Say Hi

Perhaps the best way to get into the next three weeks of study is to become acquainted with some of the things with which you will be working.

1. Obtain a clean jar or beaker. The larger the container, the better.

2. Fill the container with tap water.

3. List at least four observations about the container. Take your time; there are many which can be made.

   a) _____

   b) _____

   c) _____

   d) _____

4. Discard that sample and obtain a sample from the pond or stream supply provided. Again take your time and record four observations.

   a) _____

   b) _____

   c) _____

   d) _____

5. How many of your observations for number three were physical properties? _____ Chemical properties? _____

6. How many of your observations for number four were physical properties? _____ Chemical properties? _____

7. How many living things were you able to see in the pond or stream sample? None, a few, many? _____

You are about to embark on a study of water and the organisms which can inhabit it. Our attention will be directed to lakes and streams in Nebraska so we can really see what our water systems are like. You will have the chance to build equipment which you will use, collect live organisms, make water tests similar to those scientists make, collect data and get outdoors -- where biology and life really exist. There will be a lot to learn so keep a keen eye open. You will come to know at least one Nebraska water system very well.

Opening Your Eyes – What Do You See?

Telelesson Notes

I. Oligotrophic Lakes

Characteristics common to oligotrophic lakes

1. Clean, blue color of the water
2. Generally deep
3. Contain cold-water fish species
4. Have a high oxygen content
5. Have a low "nutrient" content
6. Huge amounts of algae and emergent vegetation are rare
7. Small numbers of organisms and organic matter
8. Microscopic plants are mostly diatoms and desmids

II. Eutropic Lakes

Characteristics common to eutropic lakes

1. Cloudy, turbid water which is usually green
2. Generally shallow
3. Contain warm-water fish species
4. Have a low oxygen content in deep waters
5. Have a high "nutrient" content
6. Algal blooms are abundant
7. Blue-green algae are predominant
8. Organisms and organic matter are abundant

III. General Characteristics of all Lakes

A. Characteristics which vary from lake to lake

1. Lake area
2. Water color
3. Geographic location
4. Types of animal organisms
5. Types of plant organisms

B. Characteristics which are similar for all lakes

1. Contain freshwater
2. Have boundaries
3. Are landlocked

IV. Definitions/Explanations

A. **Limnology** is the study of the physical, chemical and biological properties of freshwater.

B. **Freshwater** is different from marine or salt water in the amount of salts it contains. Basically, freshwater lacks the salt, sodium chloride.

C. **Ecosystems** operate as a "whole."

V. Systematic Study

Processes in a systematic (lake) study:

1. Select problems for investigation
2. Background reading
3. Hypothesize
4. Observe
5. Experiment to collect data
6. Record data
7. Analyze data
8. Make inferences or conclusions

VI. Uses of Limnological Studies

A. Recreational facility planning and development

B. Monitoring water for domestic uses

C. Agriculture

D. Flood control projects

E. Aquatic wildlife conservation

Add your own notes here:

LABORATORY TECHNIQUES

In this section you will review some past skills you may have acquired and learn some new ones. All the techniques will be used in your limnology exercises.

Microscope Technique

This is a review of the use of the microscope. You should already possess the skills necessary for lab examinations; however, a review may help you brush up and save time later.

1. Reacquaint yourself with the parts of the microscope and their functions.

2. If you move a slide to the left, which way does it appear to move through the eyepiece? _____

3. What is meant by "field of view"? _____

_____

4. How do you calculate the magnification? _____

_____

5. Prepare a wet-mount using a sample of pond water, stream water or water from another source, and view with the microscope under all powers of magnification.

Sketches:

_____X _____X _____X

6. Be sure to clean all materials and replace them. Transport the microscope correctly with one hand on the arm and the other under the base. Cover the microscope if covers are available.

Pipetting

Pipetting is a method of transferring liquids. The pipette has an opening running from end to end and has graduations along the side. The best method for using the pipette is to use a suction bulb fitted to the upper end. With a suction bulb the volume of liquid drawn into the pipette is regulated with the fingers and no oral contact is necessary. However, if no bulbs are available, you can still learn how to use it.

1. Obtain a sterile pipette.

2. Determine the total capacity of the pipette.
   Total capacity = _____ml.

3. In what units is the pipette divided? _____

4. Follow the directions closely! Liquids can be drawn into the mouth if improper techniques are used.

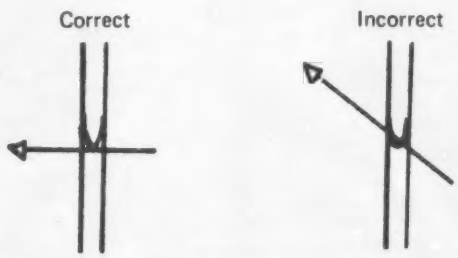
5. Place the tapered end of the pipette in a sample of drinking water. Always have the end submerged so that air bubbles do not enter the pipette and cause the liquid to quickly travel up the tube. This is very important especially when using acids.

6. If a suction bulb is available, practice drawing liquid up the pipette by using your thumb and index finger to apply pressure to the valve. If no suction bulb is available, hold the pipette with your thumb and finger. Place your mouth over the end of the pipette and slowly draw the liquid upward. When the liquid is above the level needed, quickly remove your mouth and close off the end with your index finger.

7. Now you can regulate the volume of liquid released by easing the pressured applied by your index finger.

8. Practice this technique until you are skillful in the use of the pipette.

9. To read the volume of liquid present in the pipette, observe the U shape at the upper end. Notice that it would make a difference which part of the U you read. The term for the U is "meniscus." To read the volume, sight across the bottom of the menicus.



10. Place the pipette in a container so it may be sterilized.

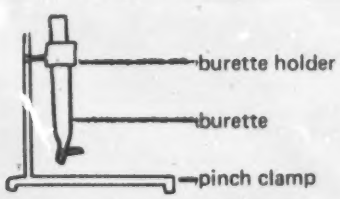
11. Clean the lab area and replace materials.

Titration

Titration is a very accurate means of determining volumes of liquids used in experiments. It may appear similar to pipetting but some of the techniques are different and a much greater degree of volume accuracy may be obtained.

1. Obtain a clean burette, ringstand, pinch clamp and burette holder.

2. Assemble the apparatus as shown below.



3. What is the capacity of the burette? _____
   Into what individual units is the burette divided? _____

4. Close the pinch clamp.

5. Using a supply beaker, fill the burette with water.

6. Open the pinch clamp to allow water to drain fr(m the burette, drop by drop.

7. Practice regulating the flow of the liquid. During actual tests, the liquid is allowed to drain drop by drop to obtain accuracy.

8. Read the meniscus.

9. Clean materials and return them tc their proper storage.

Labeling

One of the most important aspects of scientific work is correct and accurate labeling.

Be sure to include the following items on all your lables:

1. Your name

2. Sample location

3. Test to be conducted

4. Date

Labels should be applied to all chemical solutions and individual equipment if you are responsible for your own apparatus. Most importantly, label samples correctly!

Remember: If you want to know what you have, what has been done and what is to be done, use labels.

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Testing for Water Quality

Telelesson Notes

I. Sampling

Questions to consider in choosing a sample site

1. What question are we trying to answer?
2. What experimental test should be performed?
3. How many samples?
4. How many sample locations?
5. In what form is data to be recorded?
6. At what depths are samples to be gathered?

II. Record Keeping

A. Functions of record keeping

1. Collects all data
2. Useful in making inferences or conclusions
3. Useful in verifying statements made
4. Communication of the work to others

B. Hints for Better Record Keeping

1. Record immediately
2. Record accurately
3. Record completely

III. Analyzing Data

Use an organized process

1. Graph or chart data
2. Use specific data to verify or defend inferences
3. Account for all factors which may have affected the results
4. Organize a broad analysis of the entire lake system

Add your own notes here:

Field Exercise No. 1 - Temperature

Purpose To determine the temperature of water samples

Materials
Thermometer
Subsurface thermometer apparatus

Procedure

1. To determine the surface water temperature, place the thermometer in the water, allowing it to remain there for about one minute. (Be sure to shade the area.)
2. To read the temperature, tilt the thermometer to the side, keeping it in the water.
3. Record the temperature in the data table.
4. To determine subsurface water temperature, lower the apparatus into the water and allow it to remain there for about three minutes.
5. Carefully and quickly raise the apparatus and record the temperature in the data table. (Keep the thermometer shaded.)

Discussion We are all aware of the impact changing temperature has on us as land dwellers. Temperature changes also greatly affect water systems. Colder water can "hold" more oxygen, bouyancy differences affect organisms swimming in the water, and rates of growth are affected. Lakes have an annual temperature cycle. Lakes in our region undergo two temperature changes. These lakes are "dimictic lakes." This means that there are spring and fall turnovers. (di=two + mictic = mixing)

At a certain time in the spring, the temperature in the lake will be just about the same from top to bottom (about 4^{o} celsius). This occurs as a result of the thawing of the winter ice. Next, winds can create currents in the lake and set the whole body of water into motion, churning and mixing the water throughout. This is the spring turnover. The spring turnover is usually short because the surface water warms quickly. However, weather conditions play a great part in the changes which occur in the lake. Another important factor is the physical size of the lake, its area and depth. A summer stagnation can result if the lake is sheltered from the wind or if the spring thaw is immediately followed by a calm, warm period. In this case, there is a lack of mixing of the water in the deeper parts of the lake and it is possible that the bottom depths can stay like they were in the winter.

As the temperature stablizes in the summer or late spring, the lake undergoes stratification. This is a type of "layering" based on temperature differences. The colder layer at the bottom is termed the "hypolimnion," the middle transitional layer is the "thermocline" and the upper, warmer layer is the "epilimnion." Within these three layers, live communities of different organisms, based on their ability to adapt to the conditions present.

In autumn heat is lost and temperature in the lake water drops. As this proceeds, the differences in the temperatures of the three layers are reduced and wind can start the currents which begin to mix the waters again. Gradually the waters become mixed throughout and a fall turnover results. Much like the spring turnover, the duration of the fall turnover depends on weather and depth. Simply, the more water to be cooled, the longer it will take to cool it.

The last phase of the temperature cycle consists of the winter stagnation. As the temperature of the water decreases, the water begins to freeze. If calm conditions are present for a long enough time, the ice seal can be completed and temperatures will remain unchanged for the duration of the winter.

From this discussion we can see how important temperature is to the conditions and properties of lakes.

Questions

1. When obtaining a temperature reading, why is it important to be certain the bulb of the thermometer is not touching anything except the water molecules? _____ _____ .

2. Based upon temperature, lakes in our region are called _____ lakes.

3. List the four main phases of the annual temperature cycle for lakes in our region.

   a) _____

   b) _____

   c) _____

   d) _____

4. Perhaps the two most important factors affecting changes of temperatures in the lake are _____ and _____ .

5. Match the following:

   a) Thermocline _____ upper temperature region

   b) Epilimnion _____ lower temperature region

   c) Hypolimnion _____ intermediate temperature region

Field Exercise No. 2 - Turbidity

Purpose To determine the transparency of a lake or stream

Calibrated rope or twine
Secchi disc

Procedure

1. After determining a sampling site, attach the rope to the Secchi disc.
2. Slowly lower the Secchi disc into the water until it disappears.
3. Record in the data table the point, as measured on the rope, at which the Secchi disc just disappeared.
4. Lower the Secchi disc a ways beyond the point where it was no longer visible.
5. Slowly raise the Secchi disc until it is just visible.
6. Record in your data table the point at which the Secchi disc became visible.
7. Average the two readings obtained and record the turbidity value (average) in the data table.

Discussion Turbidity is a property of a lake which affects the amount of light allowed into the water, how deep the light may penetrate, the density of the water, and the amount of heat the lake can retain. One immediate observation which can be made is that the more turbid the water, the shallower the light can penetrate. This can then affect the plant life of the system—when one characteristic of a lake changes, it causes changes in other characteristics.

Another change is the amount of heat held by the water. When there are more particles which can be warmed by the sun, the water can hold a greatly increased amount of heat. This leads to changes in temperature which in turn affect the fish community as well as the remainder of the living community.

Questions

1. Define turbidity: _____
   _____
2. What instrument was used to determine turbidity? _____
   _____
3. Why was the instrument lowered until it disappeared and then raised until it reappeared to obtain measurement values? _____
   _____
   _____
4. Explain two ways in which turbidity affects a lake system. _____
   _____
   _____
   _____
5. In what units is turbidity measured? _____

Field Exercise No. 3 - Dissolved Oxygen

Purpose To collect water samples and determine the dissolved oxygen content of the samples

Materials

Two or three 250-300 ml ground-glass stoppered collection bottles
Hale's water sampler (for subsurface samples)
Manganous sulfate
Alkaline-Iodine solution
Concentrated sulfuric acid
Sodium thiosulphate
Starch solution
500 ml Erlenmeyer flask
250 ml graduate cylinder
10 ml graduate cylinder
Two 10 ml pipettes
Burette with pinch clamp
Ring stand
Burette support

Procedure Winkler Method

Steps 1 to 7 must be completed at the collection site. The remaining steps should be completed as soon as possible but a few hours may pass before results will be affected.

1. Collect surface water samples for this test by tilting the collection bottle to a horizontal position. Be very careful to allow the sample to flow into the bottle slowly and gently. This will help assure that additional oxygen is not mixed into the sample.

   To collect subsurface water samples, use the Hale water sampler. Make sure the top of the outlet tube in the reservoir bottle is at a higher level than the top of the inlet tube in the sample bottle. Lower the apparatus to the desired depth as indicated by the rope graduations. Allow plenty of time for the collection of the sample; the time required should be based on laboratory trials beforehand. Because water will fill the containers when they are lowered to the desired depth, no more can enter when the apparatus is being raised. When the sample is brought to the surface, detach the sample bottle and remove the stopper and glass tubes. The water level should be high enough in the bottle that when the ground-glass stopper is inserted, a small overflow and no inclusion of air bubbles results.

2. Fill the collection bottle until there is enough water present so that when you replace the stopper, some of the sample is forced out of the bottle and no air bubbles enter.

3. Using one pipette correctly labeled "manganous sulfate," add 1 ml of manganous sulfate beneath the sample surface.

4. Using one pipette correctly labeled alkaline-iodine, add 3 ml of the alkaline-iodine solution beneath the sample surface.

5. Replace the stopper securely, being sure to prevent air bubbles from entering. Shake the solution well for about 15 seconds. Allow the precipitate to settle until it is in the bottom portion of the bottle. If no reaction occurs quickly, shake the solution vigorously again.

6. After the precipitate has settled, use the small graduate cylinder to transfer 2 ml of concentrated sulfuric acid to the sample, applying it from above the sample surface and against the inside neck of the collection bottle.

7. Replace the stopper, being sure not to trap air bubbles, and shake the solution well.

8. Measure 200 ml of the treated sample in the large graduate cylinder and transfer it to a 500 ml Erlenmeyer flask. It may be necessary to place the mouth of the smaller flask inside the mouth of the larger one, then invert them to insure rapid transfer.

9. Using the burette, titrate your sample with the sodium thiosulfate solution. Carry out the titration procedure over a white piece of paper in order to easily see the blue color disappear. If your solution turns a faint yellow after you have added the sodium thiosulfate, add 1 to 2 ml of the starch solution.

10. Record your results in the data table.

The amount of dissolved oxygen present in your sample is represented in parts per million (ppm) by weight. This means that if you used a 200 ml collection sample, the amount of dissolved oxygen present in ppm will be equal to the number of milliliters (mls) of the sodium thiosulfate used in the titration.

Discussion

It is not necessary that you understand all the chemistry involved in this test. It is important that you understand the relationship between the amount of dissolved oxygen present in water and the organisms capable of living under those conditions.

It should be evident that organisms which need more dissolved oxygen to survive will live where the water is purer — capable of holding more oxygen. This condition for life, dissolved oxygen content, is one reason for the differences in the types of fish, insects and plants which inhabit various fresh water systems. For example, muddy water has less capability of holding oxygen than pure, clear water. Because trout require a fairly high oxygen content and cool temperatures, it is very difficult for trout to survive in many of the muddy lakes and streams found in Nebraska. However, catfish and bullhead have lower requirements for dissolved oxygen and cool temperatures and can inhabit the muddy waters.

This is just one of the many factors operating in the water system which affect the surrounding ecosystem.

Questions

1. Care must be taken, when conducting a dissolved oxygen test, to not introduce bubbles into the sample. Why?

_____
_____
_____
_____.

2. The clearer the water, the _____ the chance for greater dissolved oxygen content.

3. The unit used in determining the amount of dissolved oxygen present in a water sample is_____ _____ _____.

4. When titrating your water sample with the sodium thiosulfate solution, you have reached the end point when what occurs?_____
_____.

5. Explain the basic relationship between dissolved oxygen content of water and the organisms which can inhabit the water. _____
_____
_____

Field Exercise No. 4 - Carbon Dioxide

Purpose

To collect water samples and determine the carbon dioxide content of the samples

Materials

Two or three 250-300 ml stoppered collection bottles
Hale's water sampler (for subsurface samples)
250 ml graduate cylinder
Eyedropper
Burette with pinch clamp
Phenolphthalein indicator
Sodium hydroxide solution
Ring stand
Burette support

Procedure

1. Collect surface and subsurface samples as outlined in the dissolved oxygen test.
2. Measure a 100 ml sample and transfer to a clean collection bottle.
3. Add 10 drops of phenolphthalein indicator.
4. Using the burette, titrate your sample with the sodium hydroxide solution until a faint but permanent pink is produced. This may take about three minutes.
5. While titrating, mix the solution by swinging the bottle gently or rotating it with a circular motion of the wrist. Avoid splashing the surface of the sample since that tends to change the gas content.
6. Record your results in the data table.

   The amount of carbon dioxide in your sample is equal to 10 times the number of milliliters (ml) of the sodium hydroxide solution used.

Discussion

We know that plants use carbon dioxide to make food. ($6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$) This is true of plants which inhabit water systems as well. In the process of synthesizing or manufacturing food, the plants also release oxygen. From this relationship we can begin to explain another relationship which exists in the water system. Although this explanation is very simple, the relationship and function of carbon dioxide in the water system is very complex. Very simply, the carbon dioxide content in water affects not only the production of food and oxygen, but it also plays a role in the amount of acid found in the system and the amount of precipitates which fall to the bottom of the system. It has other effects as well.

Thus carbon dioxide is another factor which operates in the water system and affects the organisms living there.

Questions

1. The indicator used for the carbon dioxide test is _____ .
2. For the carbon dioxide test, end point is reached when a faint but permanent _____ color appears.
3. The amount of carbon dioxide present in the water affects the production of _____ by plants.
4. Explain how the carbon dioxide content of a water system is related to the kinds of organisms living there. _____

_____

_____

_____

Field Exercise No. 5 - Alkalinity

Purpose To collect water samples and determine the alkalinity of the samples

Introduction The word alkalinity also refers to base. You are aware of acids, such as sulfuric acid, battery acid, hydrochloric acid, stomach acid, citric acid (fruits). The "opposites" to acids are bases. Examples of bases are Rolaids, Maalox, ammonia and Milk of Magnesia. When acids and bases are added together, they try to neutralize each other. This same concept operates in water systems. Most water systems contain such bases as hydroxides, phosphates, carbonates, etc.
This test is used to determine the amount of these bases in the water.

Materials
Two or three 250-300 ml collection bottles
Hale's water sampler (for subsurface samples)
250 ml graduate cylinder
Two 200-250 Erlenmeyer flasks
Two eyedroppers
Burette with pinch clamp
Phenolphthalein indicator
Methyl orange indicator
Sulfuric acid

Procedure

1. Collect water samples by any method because no great danger of changing the alkalinity exists.
2. To determine the amount of hydroxides plus half the carbonates present (both are bases), measure 100 mls of the sample and transfer to an Erlenmeyer flask.
3. While holding the flask over a white surface (paper), add four drops of phenolphthalein indicator.
4. If the solution becomes colored, hydroxides and/or carbonates are present.
5. Using the burette, add sulfuric acid slowly until the coloration disappears.
6. Record the amount of acid used in the data table. The phelolphthalein alkalinity is calculated in parts per million (ppm). This is equal to 10 times the number of milliliters (mls) of the sulfuric acid used.
7. To determine the total alkalinity of the sample, measure 100 mls of the sample and transfer to an Erlenmeyer.
8. While holding the flask over a white surface (paper), add two drops of methyl orange indicator.
9. If the solution becomes yellow, bases are present.
10. Using the burette, add sulfuric acid slowly until the color of the solution is no longer pure yellow.
11. Record the amount of acid used in the data table. The methyl orange alkalinity is also calculated in parts per million (ppm). This is equal to 10 times the number of milliliters (mls) of the sulfuric acid used.

Discussion

Just as all chemicals in a water system affect the quality of the water, they also help regulate which types of organisms can inhabit the water. The collection of chemicals which contributes to alkalinity plays a role in the bouyancy, density, clarity and physical appearance of the system. Together these chemicals have a profound effect on the system but you will study phosphate and nitrate to determine their individual impacts on the water system. At this point, you should recognize that bases effect water systems by changing the living conditions in the water and thus the organisms which may life there.

Questions

1. The word alkalinity also refers to _____.

2. Give two examples of bases (not commercial products):

   a) _____

   b) _____

3. When acids and bases are added together, they attempt to _____ each other.

4. Name one of the two indicators used to determine alkalinity:

   _____

5. The most important effect of alkalinity on a lake system is its eventual effect on what? _____

   _____.

Field Exercise No. 6 - Acidity pH

Purpose To collect water samples and determine the acidity of the samples

Introduction The acidity test of water samples is also a measure of the alkalinity. This is true because the more acidic a samples is, the less alkaline or basic it is. Likewise, the less acidic it is, the more basic it is. This test is another method of determining alkalinity or, acidity.

Materials
Collection bottle
Five test tubes
pH papers or indicator solutions
Color comparison chart or indicator solutions
Potentiometer (if available)

Procedure

1. Collect samples using any method, but try to avoid excess jarring of the contents.
2. If a potentiometer is available, complete the test.
3. If using pH paper, use a small piece and wet the end. Then compare the color to the color chart which accompanies the paper.
4. If using indicator solutions, put a small samples of test water into a test tube (3 ml will be enough).
5. Choose an indicator solution you feel will be close to the actual pH and add a few drops to the sample.
6. Do not invert the test tube against your finger in order to mix the contents. This will contaminate the results. To mix the contents, use a circular action of the wrist.
7. If necessary, use another test tube and follow the procedure in number 5 using a different indicator solution.
8. Record the pH value obtained in your data table.

The following table gives the pH range of different indicators.

Indicator	pH Range
Brom cresol purple	5.2 - 6.8
Brom thymol blue	6.0 - 7.6
Phenol red	6.8 - 8.8
Cresol red	7.2 - 8.8
Thymol blue	8.0 - 9.6

Questions 1. Give an example of an acid: _____

Questions 2. Name at least two indicators which may be used to determine pH:

a) _____

b) _____

3. Why don't you shake up the contents of the test tube using your finger on the open end of the tube? _____

_____

_____

_____

25

Field Exercise No. 7 - Phosphates

Purpose

To collect water samples and determine the presence or absence of phosphates in the samples
(This is a qualitative test.)

Materials

Standard solutions
Silver nitrate solution
Eyedropper
Two test tubes
Collection bottles
10 ml graduate cylinder or 10 ml pipette

Procedure

1. Collect water samples by any method because no great danger of changing the phosphate content exists.

2. From your sample bottle, transfer 5 ml of sample water to a test tube using either a 10 ml graduate cylinder or a 10 ml pipette.

3. Using the eyedropper, add 10 drops of the silver nitrate solution to the test tube.

4. Mix the contents by gently rolling the test tube between the palms of your hands. (Do not mix by placing your finger over the open end of the test tube and shaking!)

5. Keeping in mind that a slight yellowish color is present naturally in this test and does not indicate phosphate, compare your test solution to the standard solutions prepared.

6. Determine the approximate phosphate content of your sample by color comparison.

7. Record the results of the test in your data table.

Discussion

You have already found that phosphates contribute to the alkalinity of a water system. Yet phosphates by themselves have an effect on the water system and its inhabitants. In the past, concern arose about the phosphate found in detergents which were said to be polluting water systems. This concern resulted in the production of no-phosphate detergents.

The effect of phosphate on water systems is related to algal growth. Phosphorous is one of the important parts of living matter. In this way phosphorous is one of the "foods" for living cells. Phosphate contains phosphorous, which may be the most important ecological factor in water systems. It is thought that the phosphate level is a controlling factor in the rate of algal growth. The importance of this concept lies in the eventual effect on the water system. With the increased growth of algae, a larger volume of algae will die. To decompose this larger volume of algae, more oxygen will be used. With the increased demand on the oxygen supply, changes in the living community can occur.

Again, we can see the importance of phosphate as one component of the water system.

Questions

1. Phosphate content in a water system is related to the amount of _____ growth.

2. What chemical element may be the most important ecological factor related to algal growth? _____

3. The phosphate test you conducted is which type of analytical test, quantitative or qualitative? Why? _____

Field Exercise No. 8 - Nitrates

Purpose

To collect water samples and determine the presence or absence of nitrates in the samples
(This is a qualitative test)

Materials

Standard solutions
Ferrous sulfate solution
Eyedropper
Two test tubes
Collection bottles
Two 10 ml graduate cylinder or 10 ml pipette
Concentrated sulfuric acid

Procedure

1. Collect water samples by any method because no great danger of changing the nitrate content exists.
2. From your sample bottle, transfer 5 ml of sample water to a test tube by using either a 10 ml graduate cylinder or 10 ml pipette.
3. Using the remaining graduate cylinder or pipette, add 5 ml of the ferrous sulfate solution to the test sample.
4. Very slowly add one eyedropper full of concentrated sulfuric acid down the side of the test tube.
5. A positive test for nitrates is indicated by a brown ring located between the test solution layer and the acid layer. Observe your test.
6. Record the results of the test in your data table.

Discussion

Like phosphorous, nitrogen is used by plants to grow. Nitrate is a source of nitrogen and so is important to the water system. However, too much of anything can be bad. This is the case with large increases of nitrogen to the system. The increased algae growth (usually blue-green algae) clouds the water and oftentimes forms a scum on the surface. In addition, some of the types of blue-green algae are not widely used as a food source. Thus the predator control is reduced. One other possibility is the production of substances which are toxic to animals. From this description you can see the possible effects which result from increased nitrate levels in water systems.

Questions

1. Nitrate is a source of _____ for the growth of living cells.
2. One of the more important types of algae associated with increased nitrate levels is _____
3. What is meant by "toxic substance"? _____
   _____
4. What two chemicals seem to be the most important in algae bloom problems associated with water systems?

   a) _____

   b) _____

Lakes: Living Communities

Telelesson Notes

I. Equipment for Collecting Samples

A. Open water sampler
   Clark-Bumpus sampler

B. Bottom-mud sampler
   Ekman Dredge

C. Shoreline sampler
   Dipper
   Coffee can

II. Method of Storage of Organisms

A. Live preservation
   Bottles put on ice
   Storage in aquarium or large tub

B. Non-living preservation
   Formalin solution (10 per cent)

III. Importance of Organisms to Lake Study

1. Functional as part of the lake ecosystem
2. Offer important clues to the operation and problems of the lake
3. Aid in making accurate inferences

IV. Aids in Transfer of Organism

1. Tighten lids
2. Mask all glass collection jars
3. Pack container carefully

V. General Aids in Collecting Organisms

A. Prepare apparatus beforehand
   1. labels
   2. checklist

B. Read and discuss lab beforehand
   1. learn procedures
   2. review techniques

C. Safety
   Review rules to be followed

Add your own notes here:

Getting It All Together

Telelesson Notes

I. Limnology Equipment

A. For physical tests
   1. Hack kit
   2. PH meter
   3. Centrifuge
   4. Mixer

B. Instruments used in studying organisms
   1. Microscope
   2. Hand lens
   3. Microscope slides
   4. Cover slips
   5. Reference materials

II. Organisms Commonly Found in Freshwater Lakes

A. Microscopic organisms
   1. Algae
   2. Protozoans
   3. Rotifers

B. Larger organisms
   1. Molluses
   2. Crustaceans
   3. Insects
   4. Fish

III. Relationships Among Components of a Lake System

A. Water quality—organism relationships

B. Organism-organism relationships

C. Organism-habitat relationships

IV. Characteristics of Limnological Study

A. Observing

B. Hypothesizing

C. Experimenting

D. Collecting specimens

E. Record keeping

F. Analyzing data

G. Making inferences and conclusions

V. Future of Limnological Research

A. Recreation management

B. Water consumption management

C. Wildlife management

VI. Careers and Education

A. B.S. Degree
   1. Class requirements
   2. Jobs available

B. M.S. Degree
   1. Class requirements
   2. Jobs available

C. Ph.D. Degree
   1. Class requirements
   2. Jobs available

D. Other Degrees

Add your own notes here:

Field Exercise No. 9 - Shoreline Sampling

Purpose To collect and preserve plant and animal specimens from a shoreline area

Materials
White dish (7" x 10" x 2" is best)
Hand lifter or forceps
Hand lens
Wire pillow cage
Small garden hand spade
Collection jars
70 per cent alcohol
Ice
Labels

Procedure

1. Locate a sampling site and record its location in your data table.
2. Do not wander into the water!
3. Using the hand spade, carefully and gently dig a sample of shoreline soil and place it in the white dish. Raise the sample slowly as the water may wash away some specimens.
4. Use the lifter or forceps to pick up the organisms, being careful not to injure them. (Observe them using the hand lens.)
5. For temporary storage of the larger organisms, place them in the pillow cage. Then immerse the pillow cage in the lake water to keep the specimens alive.
6. Conclude specimen collections.
7. Transfer the specimens to collection jars. You should separate the dragonfly nymphs, diving beetle larvae and other carnivores so they do not kill the soft-bodied organisms. Such things as "moss," algae, small plants, leaves can be included.
8. Label the jars correctly. Include name, lake and area.
9. If possible, leave the jars open so that ample oxygen is available.
10. Place the collection jars on ice for transfer to the lab. If preservation is to be utilized, place the specimens in 70 per cent alcohol.
11. Clean all equipment and load materials to be taken back to the classroom.

Questions

1. What is the advantage of having class members sample in different areas?

2. Why are organisms stored at colder temperatures if you want to observe them alive at a later time? Explain.

3. Describe one observation you have made, while collecting samples, which involves the sampling techniques.

Field Exercise No. 10 - Open Water Sampling

Purpose To collect and preserve plant and animal specimens from an open water area

Materials

White dish (approximately 7" x 10" x 2" enamel is best)
Plankton net
Hand screen (stream collections)
Life preserver
Collection jars
Boat (optional)
Hand lifter
Labels
Ice
70 per cent alcohol solution
Tape measure

Procedure

1. Review safety precautions!
2. Obtain a life preserver and wear it.
3. Select a sampling site and record its location in the data table.
4. Collect your samples using one of the following methods:
   a. To use the plankton net (aboard a boat), lower it into the water with the open end facing the direction in which you will move. Proceed in the water at a slow speed for a short distance, recording the distance you traveled in the data table. Remove the net from the water and empty the contents into collection jars, adding water from the collection site until the jars are about full. Do not fill them to the top because splashes from the contents may carry organisms. It is best not to seal the jars because this reduces the oxygen supply and can kill the organisms. Measure the diameter of the opening of the plankton net and record it in the data table.
   b. If no boat is available, follow the steps in part a, close to shore, under qualified supervision.
   c. One person should manipulate the hand screen. Place the screen in the stream facing the current. Another person upstream turns over stones. The organisms which are washed free will be collected on the screen. Lift the screen from the stream and transfer the larger organisms to collection jars. To obtain the smaller organisms, dump the catch into a white dish. To insure that all specimens have been removed from the screen, put the handles together and hit the screen against your palm over the dish. Next put the remaining specimens in collection jars which have been properly labeled.
5. Now is a good time to observe the organisms with a hand lens.
6. Place the collection jars on ice for transfer to the lab. If non-living preservation is to be used, place the specimens in 70 per cent alcohol.
7. Clean all equipment and load materials to be taken back to the classroom.

Collection site data

1. Description of collection site:

_____

_____

_____

2. Distance traveled using plankton net (in meters) = _____

3. Diameter of plankton net opening (in centimeters) = _____

4. Area of plankton net (in centimeters squared) = _____

Questions

1. When specimens are going to be examined at a time much later than collection, why is alcohol used for preservation? _____

_____

_____

2. Why is a white examination tray advantageous? _____

_____

_____

3. Describe one observation you have made, while collecting samples, that involves the sampling techniques. _____

_____

_____

_____

_____

_____

Field Exercise No. 11 - Bottom Mud Sampling

Purpose

To collect and preserve plant and animal specimens from the bottom mud

Materials

White dish (approximately 7" x 10" x 2")
Hand lifter or forceps
Hand lens
Coffee can
Wire pillow case
Small garden hand spade
Section of two to four inch tubing
Collection jars
Ice
70 per cent
Labels

Procedure

1. Review safety precautions!
2. Obtain a life preserver and wear it.
3. Locate a sampling site and record its location in the data table.
4. Collect your samples using one of the following methods:
   a. If you are collecting close to shore using a coffee can, push the can down into the bottom mud and bring up the sample to be examined. Empty the contents into the white dish.
   b. If you are sampling close to the shore and using the hand spade, simply collect a quantity of mud and place it in the dish for examination.
   c. If you have a section of tubing or pipe, drive it into the mud to obtain a sample. Then empty the sample into the dish. You can make population counts by using this method.
5. Separate the various organisms so that none of the soft-bodied specimens are crushed by debris. Larger organisms may be stored in the pillow cage in the water until departure to the classroom.
6. Use the hand lens to observe the specimens you have collected.
7. Transfer the organisms to collection jars. Be sure to carefully sort them into compatible groups.
8. Label all jars correctly.
9. Place the jars on ice for transfer to the lab or use the 70 per cent alcohol preservation if necessary.
10. Clean all equipment and load all materials to be taken back to the classroom.

Collection site data

1. Description of collection site: _____

2. a. Using a coffee can
   (1) height of coffee can = _____ cm.

   (2) diameter of coffee can = _____ cm.

   b. Using a section of tubing or pipe
   (1) height to which sample was obtained = _____ cm.

   (2) diameter of tubing or pipe = _____ cm.

Questions

1. What is the significance of carefully sorting the specimens for transfer to the lab? _____

2. Why is it important to record the sampling site? _____

3. Describe one observation you have made, while collecting samples, that involves the sampling techniques. _____

Field Exercise No. 12 - Examination of Shoreline Samples

Purpose To observe and identify plant and animal specimens collected from a shoreline area

Materials

Shoreline samples
Microscope
Binocular dissecting scope
Glass slides
Cover slips
Petri dishes
Hand Lens
Eyedropper
Forceps
Water supply
Identification key

Procedure

1. Obtain a shoreline sample collection jar.
2. If specimens have been kept alive, observe the motions of various organisms.
3. Carefully obtain various organisms and use the laboratory equipment to identify them. These identifications should be recorded. If working with living specimens, it is best to keep the organism moist.
4. After identifying various examples, clean all the equipment and return the equipment to its proper storage. Any specimens remaining should be disposed of according to the directions of your instructor.

Data

Scientific Name	Phylum	Description or Sketch	Estimated Number
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Questions

1. Which organism appeared to be the most abundant? _____

2. Relate the living conditions required by the organism you recorded in No. 1 to its presence in the lake you sampled. _____

3. What type of lake do the organisms you have identified usually live in, oligotrophic or eutrophic? Why? _____

4. What is meant by life cycle? Name at least two of the stages most often found in the life cycles of insects. _____

Field Exercise No. 13 - Examination of Open Water Samples

Purpose To observe and identify plant and animal specimens collected from an open water area.

Materials
Open water samples
Microscope
Binocular dissecting scope
Glass slides
Cover slips
Petri dishes
Hand lens
Eyedropper
Forceps
Water supply
Identification key

Procedure

1. Obtain an open water collection jar.
2. If specimens have been kept alive, observe the motions of various organisms.
3. Carefully obtain various organisms and use the laboratory equipment to identify them. These identifications should be recorded along with population counts. If working with living specimens, it is best to keep the organisms moist.
4. After identifying and counting various examples, clean and return all equipment to its storage. Any specimens remaining should be disposed of according to the directions of your instructor.

Data

Scientific Name	Phylum	Description or Sketch	Estimated Number
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.		40	
10.			

Calculations

1. To obtain a population estimate, use the information given below.

   V = volume of sample (in cubic centimeters)
   D = distance traveled using plankton net (in meters)
   d = diameter of plankton net opening (in centimeters)
   r = radius of plankton net opening (in centimeters)

   $V = \pi r^2 \times D$
   $V = (3.14)\ (\frac{1}{2}d)^2 \times D$

2. Calculate the volume of the lake sampled by using the above formula. Be sure to convert all units as necessary.

   V = _____

3. Count the number of specimens of one specie and determine the population count by using this formula:

   N = number of specimens of one specie
   V = volume of sample (in cubic centimeters)

   $\text{Population count} = \frac{N}{V}$

   To express the count for each cc of lake sample, reduce the fraction and divide .

4. Determine the population counts for at least three species below.

Species	Value of Sample	Number of Specimens
1.		
2.		
3.		

Questions

1. For what reasons would population counts be useful to the limnologist?

   _____

   _____

   _____

2. Which specie had the highest population count according to your results?

   _____

3. What factors may cause changes in population counts from time to time?

   _____

   _____

   _____

   _____

Field Exercise No. 14 - Examination of Bottom Mud Samples

Purpose

To observe and identify plant and animal specimens collected from the bottom mud.

Materials

Bottom mud samples
Microscope
Binocular dissecting scope
Glass slides
Cover slips
Petri dishes
Hand lens
Eyedropper
Forceps
Water supply
Identification key

Procedure

1. Obtain a bottom mud sample collection jar.
2. If specimens have been kept alive, observe the motions of various organisms.
3. Carefully obtain various organisms and use the laboratory equipment to identify them. These identifications should be recorded. If population counts are going to be made, the number of organisms should also be recorded. If working with living specimens, it is best to keep the organisms moist.
4. After identifying and counting various organisms, clean and return all equipment to its proper storage. Any specimens remaining should be disposed of according to the directions of your instructor.

Data

Scientific Name	Phylum	Description or Sketch	Estimated Number
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Calculations

A. Using a coffee can

Determine the volume of your sample by using the formula: $V = (3.14)(\frac{1}{2}d)^2 \times D$. Here D = the height of the can in cm.

V = _____

Using the estimated number of organisms you counted, determine the population count by using this formula: P count = $\frac{N}{V}$. Express the value per cubic centimeter.

lake bottom mud

Pc = _____

B. Using a section of tubing or pipe

Follow the steps in part A, except that the value for D is found by determining how high into the tube the sample was collected. Express this distance in cm.

V = _____

Pc = _____

Questions

1. Which organism seemed to be the most plentiful in your bottom mud sample? _____

2. What conditions may be present in the bottom mud as indicated by the organisms you found in your sample? _____

3. How may the collection site selections greatly affect the results of the population counts you obtained? _____

Independent Project

You should design your own project. Further study based on past exercises or new ones which combine exercises is optimal. However, this should not hinder you from designing new ones. Your project should contain a purpose, a materials list, a procedure and a conclusion. After writing your proposal be sure to have your instructor check it over with you for possible suggestions. A word of caution: try to keep your project within very well-defined limits. Too often projects are not completed because they become too big to handle.

DATA TABLES

1. Temperature

Group Table

Sample Location:	Temperature
Surface	
Trial 1	_____
Trial 2	_____
Trial 3	_____
Average	_____ °C
Subsurface	
Trial 1	_____
Trial 2	_____
Trial 3	_____
Average	_____ °C

Class Table

Group	Surface Temperature (Ave. of trials)	Subsurface Temperature
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____
9.	_____	_____
10.	_____	_____
	Average____°C	Average____°C

2. Turbidity

Group Table

Sample Location:

Trial	Depth When Lowered	Depth When Raised	Average Depth
1			
2			
3			
		Average _____	

Class Table

Group	Depth
1.	_____
2.	_____
3.	_____
4.	_____
5.	_____
6.	_____
7.	_____
8.	_____
9.	_____
10.	_____
Average	_____

3. Dissolved Oxygen

Group Sample Location:

	*Depth	Volume of Sodium Thiosulfate used	Dissolved Oxygen Present (ml)	Dissolved Oxygen Present (ppm)
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				
Group 8				
Group 9				
Group 10				

*Record both surface and subsurface temperatures in this column and calculate the values for each in the other columns.

4. Carbon Dioxide

Group Sample Location:

	*Depth	Volume of Sodium Hydroxide Used	Volume of Carbon Dioxide Present (ml)
Group 1			
Group 2			
Group 3			
Group 4			
Group 5			
Group 6			
Group 7			
Group 8			
Group 9			
Group 10			

*Record both surface and subsurface temperatures in this column and calculate the values for each in the other columns.

5a. Phenophthalein Alkalinity

Group Sample Location:

	*Depth	Presence of Colored Solution After Indicator Added (+ or –)	Volume of Sulfuric Acid Used (ml)	Phenophthalein Alkalinity Present (ppm)
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				
Group 8				
Group 9				
Group 10				

*Record both surface and subsurface temperatures in this column and calculate the values for each in the other columns.

5b. Total Alkalinity

Group Sample Location:

	*Depth	Presence of color after Methyl Orange added (+ or –)	Volume of Sulfuric Acid Used (ml)	Methyl Orange Alkalinity (ppm)
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				
Group 8				
Group 9				
Group 10				

*Record both surface and subsurface temperatures in this column and calculate the values for each in the other columns.

6. pH

Group Sample Location:

	*Depth	pH Paper Value	Indicator Used	pH Value
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				
Group 8				
Group 9				
Group 10				

*Record both surface and subsurface temperatures in this column and calculate the volumn for each in the other columns.

7. Phosphate

Group Sample Location:

	*Depth	Phosphate Present			
		–	+	++	+++
Group 1					
Group 2					
Group 3					
Group 4					
Group 5					
Group 6					
Group 7					
Group 8					
Group 9					
Group 10					

*Record both surface and subsurface temperatures in this column and calculate the volume for each in the other columns.

8. Nitrate

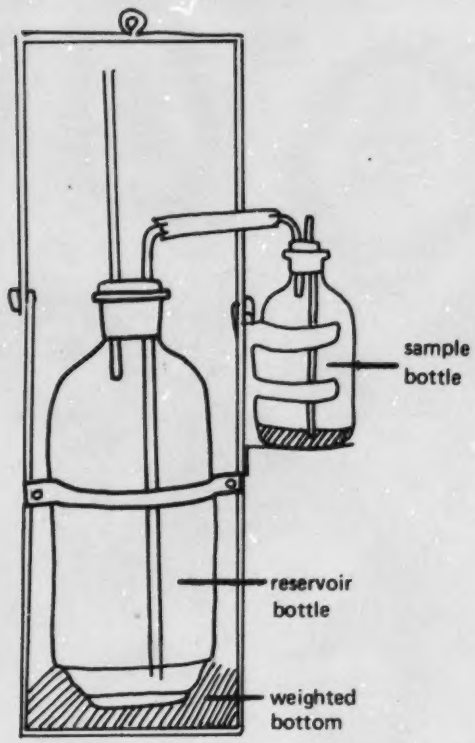
Group Sample Location:

	*Depth	Nitrate Present			
		–	+	++	+++
Group 1					
Group 2					
Group 3					
Group 4					
Group 5					
Group 6					
Group 7					
Group 8					
Group 9					
Group 10					

*Record both surface and subsurface temperatures in this column and calculate the volume for each in the other columns.

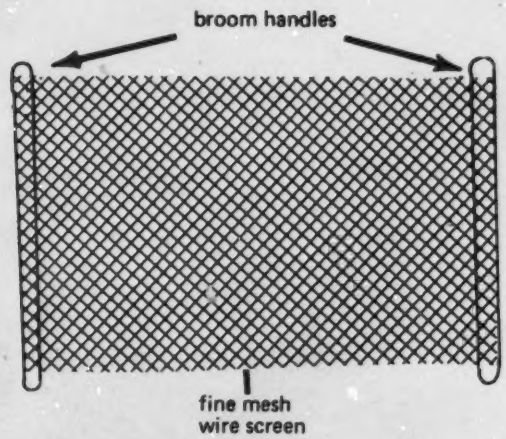
APPARATUS DIAGRAMS

1. Hale's Water Sampler



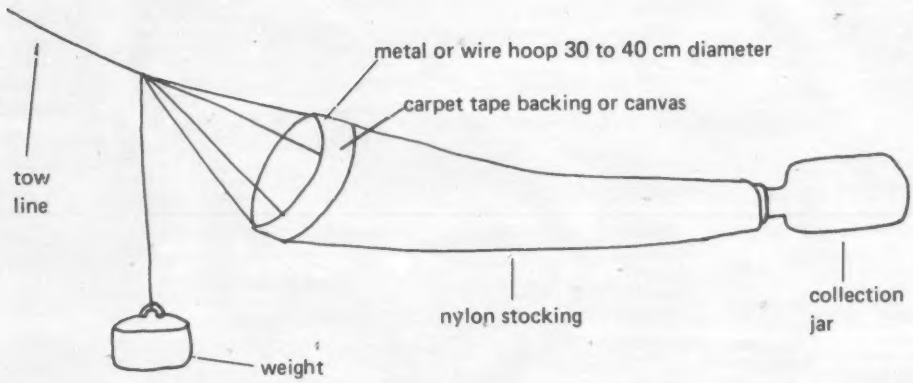
The reservoir bottle must have at least a sixfold capacity over that of the sample bottle. The top of the outlet tube in the reservoir bottle must be at a higher level than the top of the inlet tube to the sample bottle.

2. Hand Screen

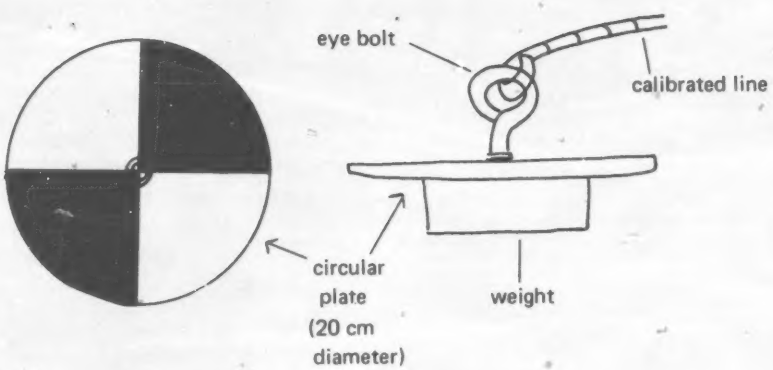


Any width is functional. The size of the mesh will determine the size of organisms which can be collected. Suggested wire screen size is 1 x 2 feet with a rolled edge on the bottom.

3. Plankton Net

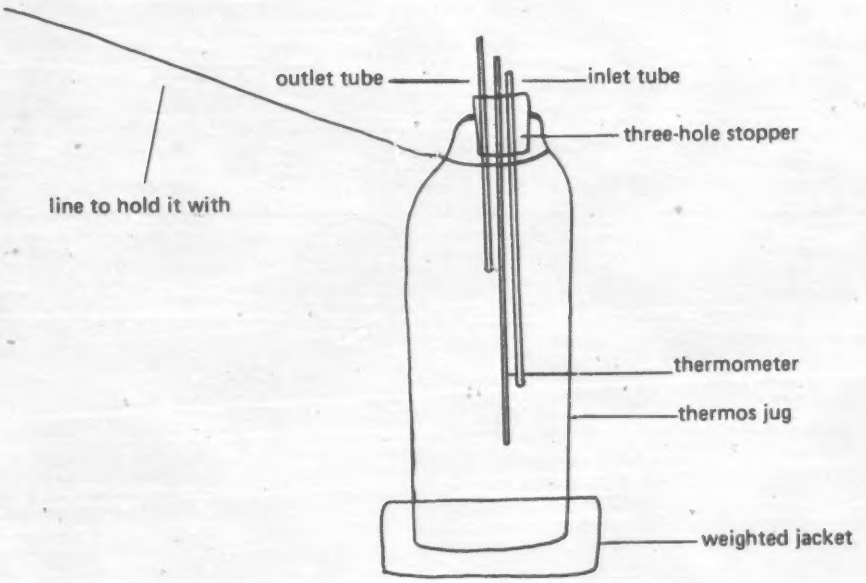


4. Secchi Disc

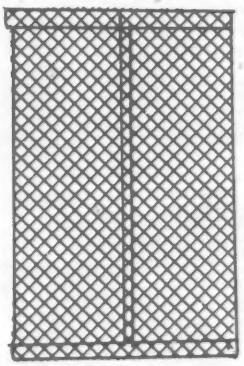


The lower surface and two alternate quadrants are painted black; the other two quadrants are white.

5. Subsurface Thermometer Apparatus



6. Wire Pillow Cage



Made from a square of wire screen--edges are folded together to make seams. The cylinder edge should be rolled first. Specimens are placed inside and one end is opened and closed as needed. A quarter of a square yard will make one cage.